



Future ATM Concepts Evaluation Tool (FACET) Background, Capabilities and Plans

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Background

- **Conducting research in En Route and TFM as part of AATT and VAMS**
- **Developed a modeling and simulation capability: Future ATM Concepts Evaluation Tool (FACET)**
- **Capability useful for both real-time applications and off-line analysis**
- **FACET has been provided to FAA, industry, small companies and universities**
- **Working with the airlines and FAA to customize the capability for specific uses**



Outline

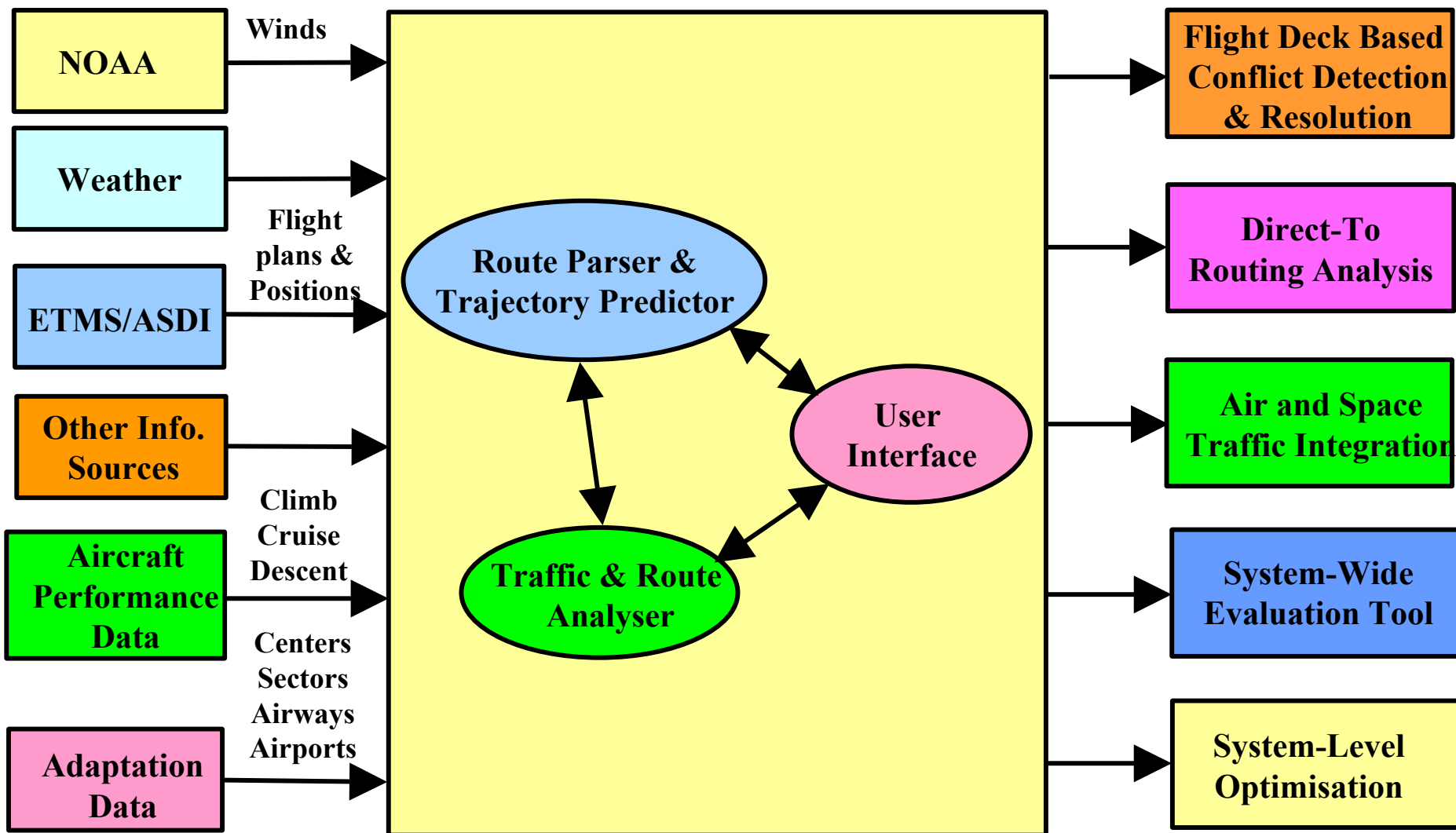
- **FACET Simulation and Modeling Capability**
- **Applications**
 - Direct-To benefits
 - Traffic Flow Management
- **Demonstration**



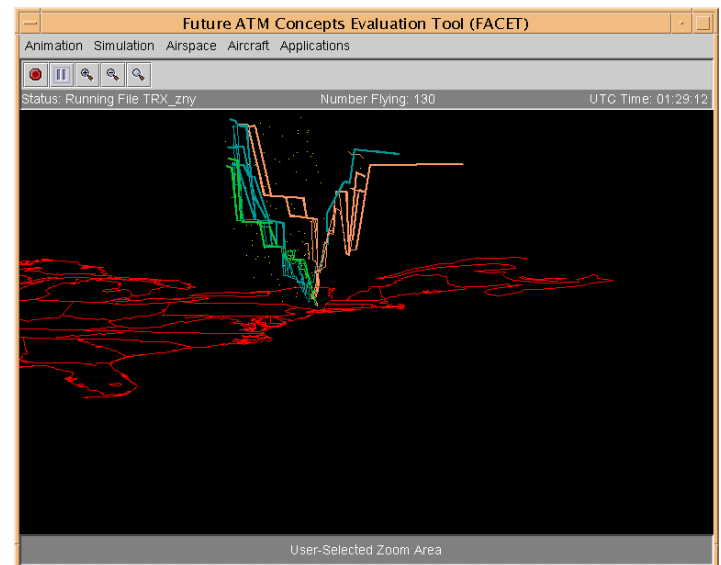
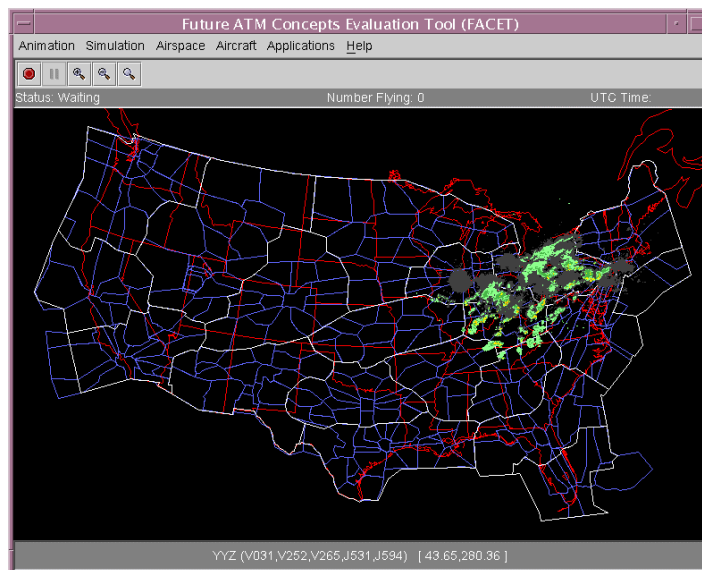
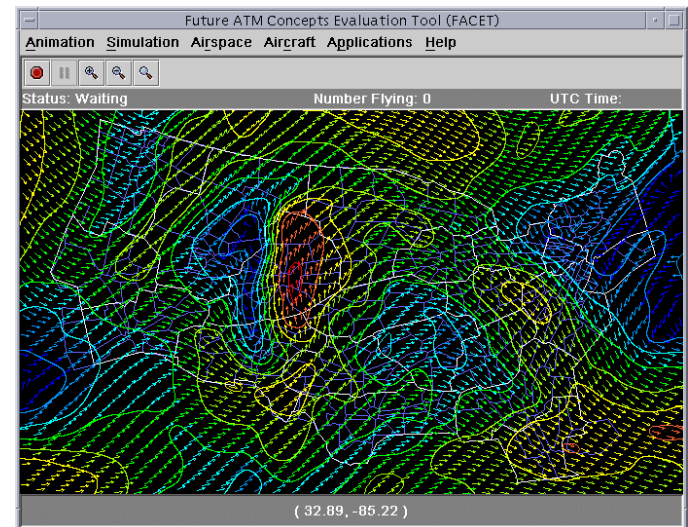
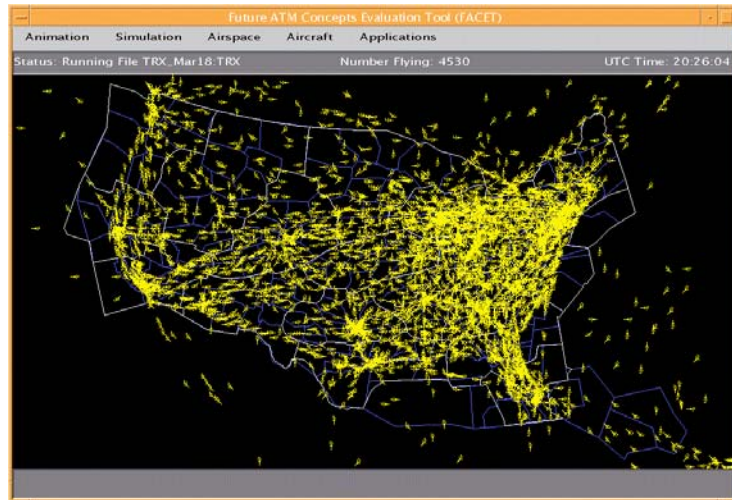
Future ATM Concepts Evaluation Tool (FACET)

- **Simulation tool for exploring advanced ATM concepts**
- **Balance between fidelity and flexibility**
 - Model airspace operations at U.S. national level (~10,000 aircraft)
 - Modular architecture for flexibility
 - Software written in “C” and “Java” programming languages
 - » Easily adaptable to different computer platforms
 - » Runs on Sun, SGI, PC and Macintosh computers
- **Used for visualization, off-line analysis and real-time planning applications**

FACET Architecture



FACET Display



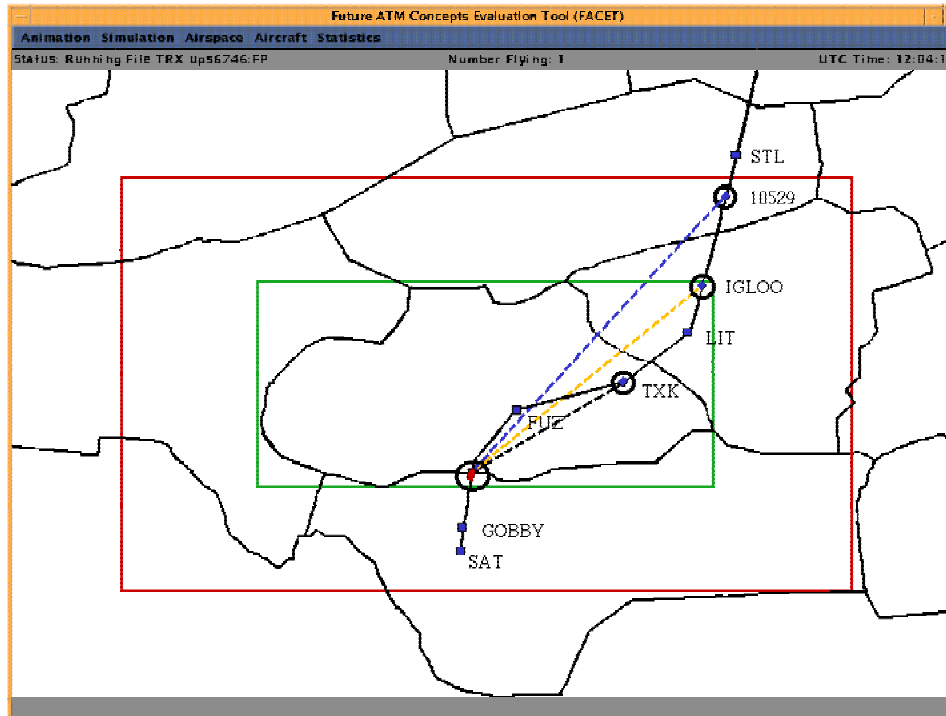
Direct-To Controller Tool (D2)

- **Direct-To (D2) is a decision support tool which enables en route radar controllers to work traffic more efficiently and facilitate flying time savings for airspace users.**
- **D2 has three main functions: conflict probe alerts, direct route advisories, and a “what-if” trial planner**
 - Conflict probe alerts and route advisories update every 12 seconds with fresh radar track data.
 - Trial plan analysis updates within 1 second in response to controller inputs and track updates.
- **An automatic wind-route analysis on all aircraft identifies conflict-free direct routing opportunities that could save at least 1 minute flying time**
- **D2 is fully integrated with the radar controllers primary traffic situation displays. Sparse and efficient information display and rapid response interactive functions are key aspects of the user interface.**



BENEFITS AT FORTWORTH CENTER

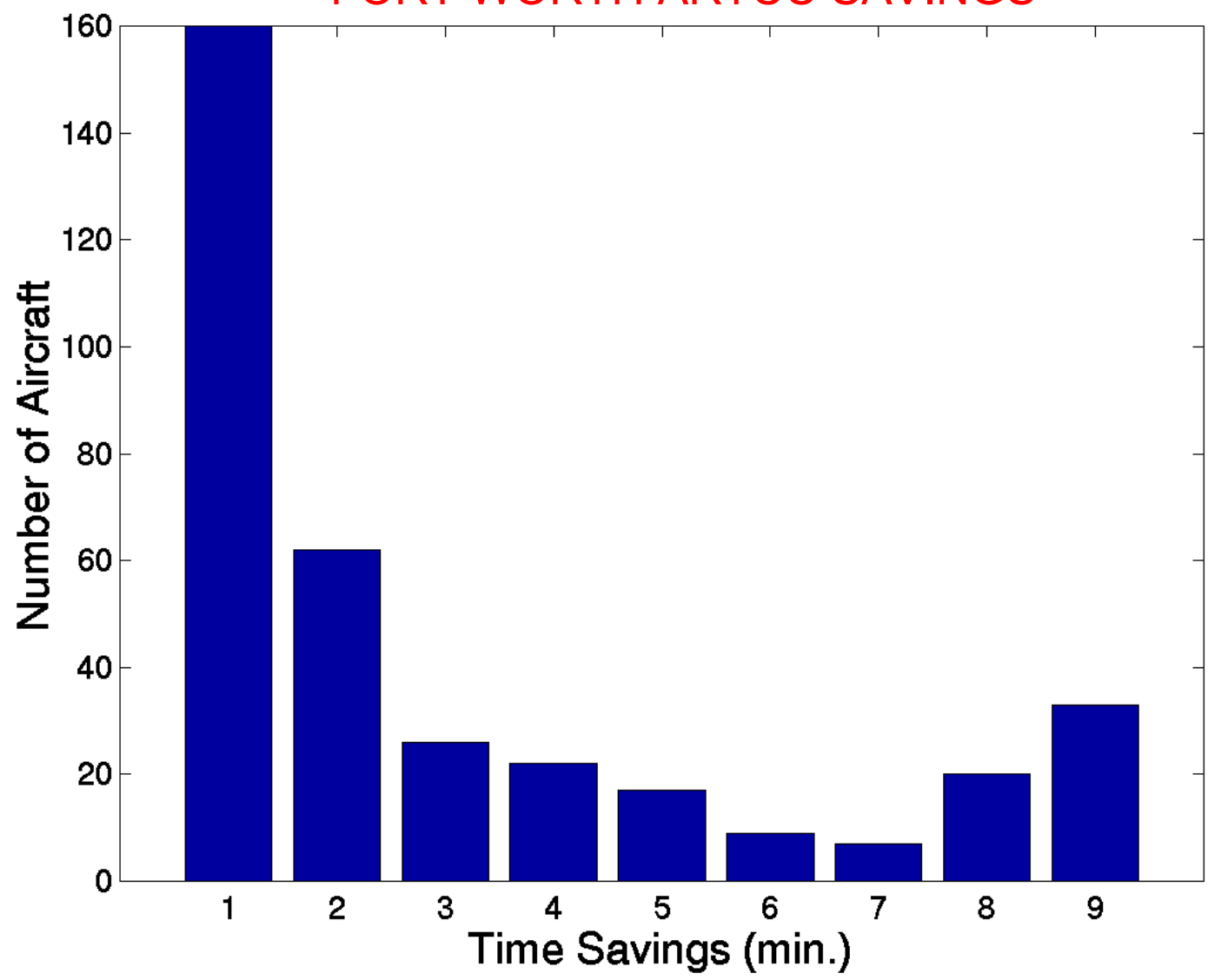
- 24 hours of ETMS data processed in FACET using different windows



SEARCH AREA	NUMBER OF AIRCRAFT	TOTAL SAVINGS (HOURS)	SAVINGS PER AIRCRAFT (MINUTES)
1000 X 600	349	20.6	3.5
633 X 293	139	10.3	4.1
ARTCC	113	7.8	4.4



FORT WORTH ARTCC SAVINGS



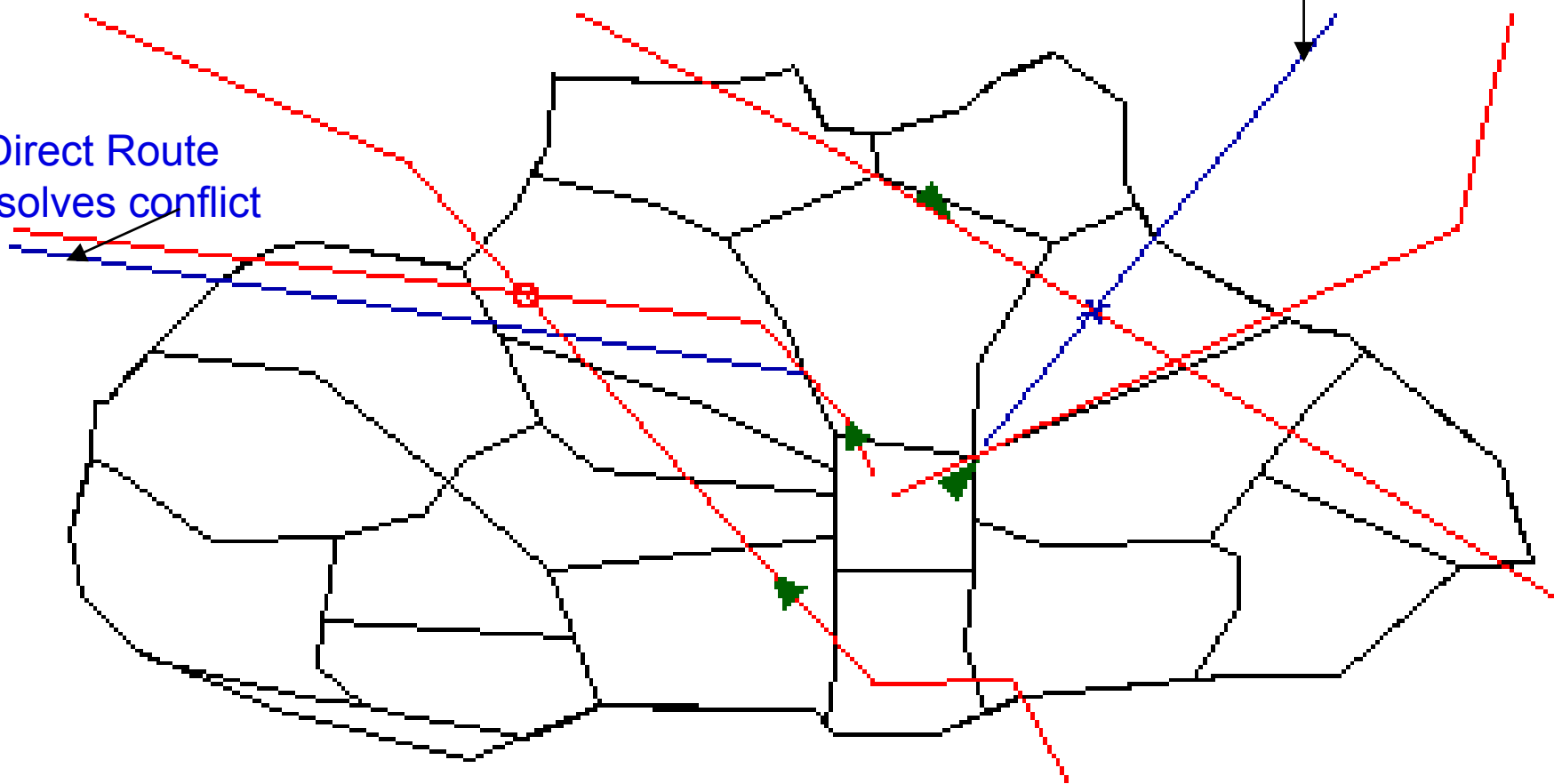
LOCATION OF CONFLICTS

— Flight Plan Route

— Direct Route

Direct Route
Creates conflict

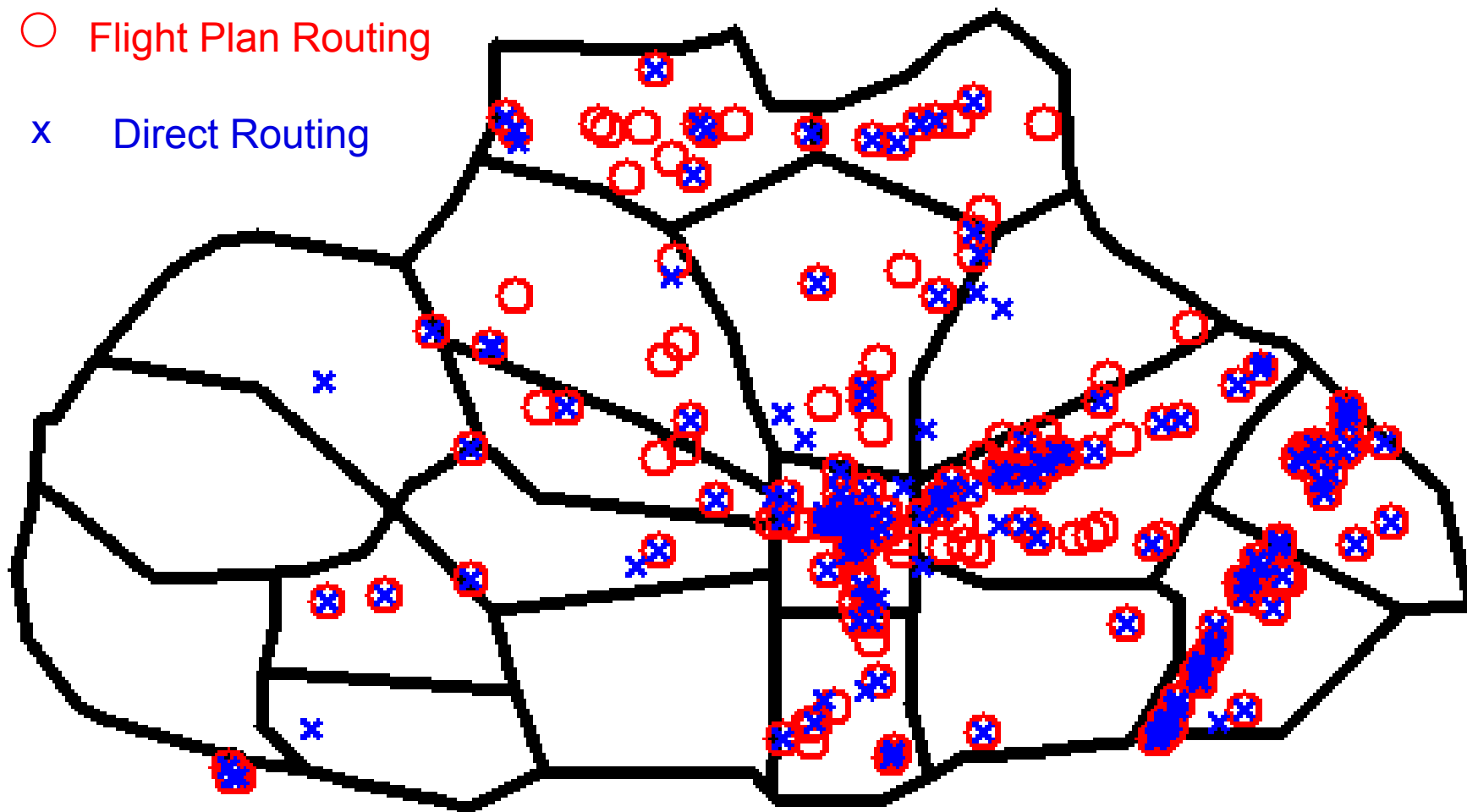
Direct Route
Resolves conflict



SPATIAL DISTRIBUTION OF CONFLICTS

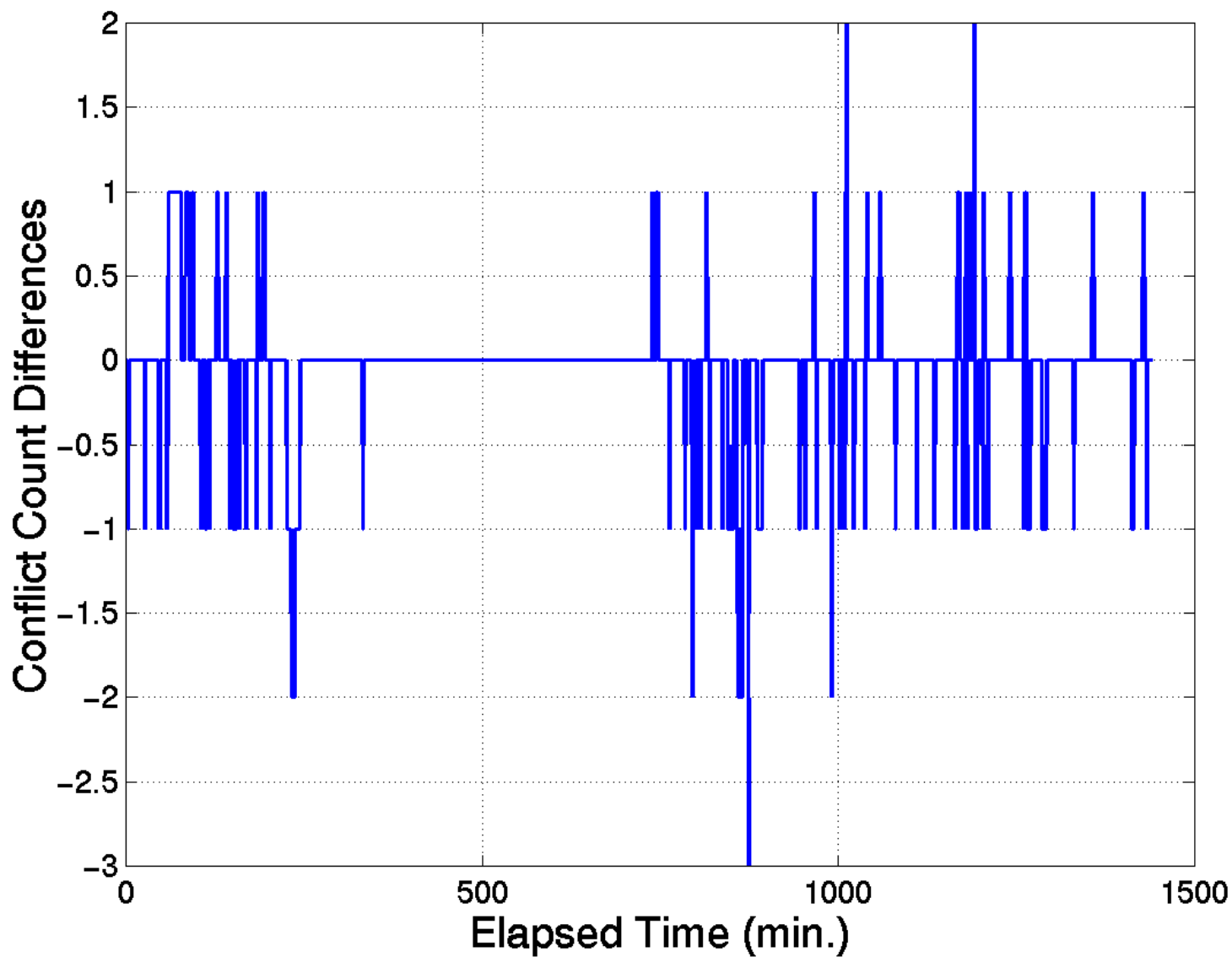
○ Flight Plan Routing

x Direct Routing



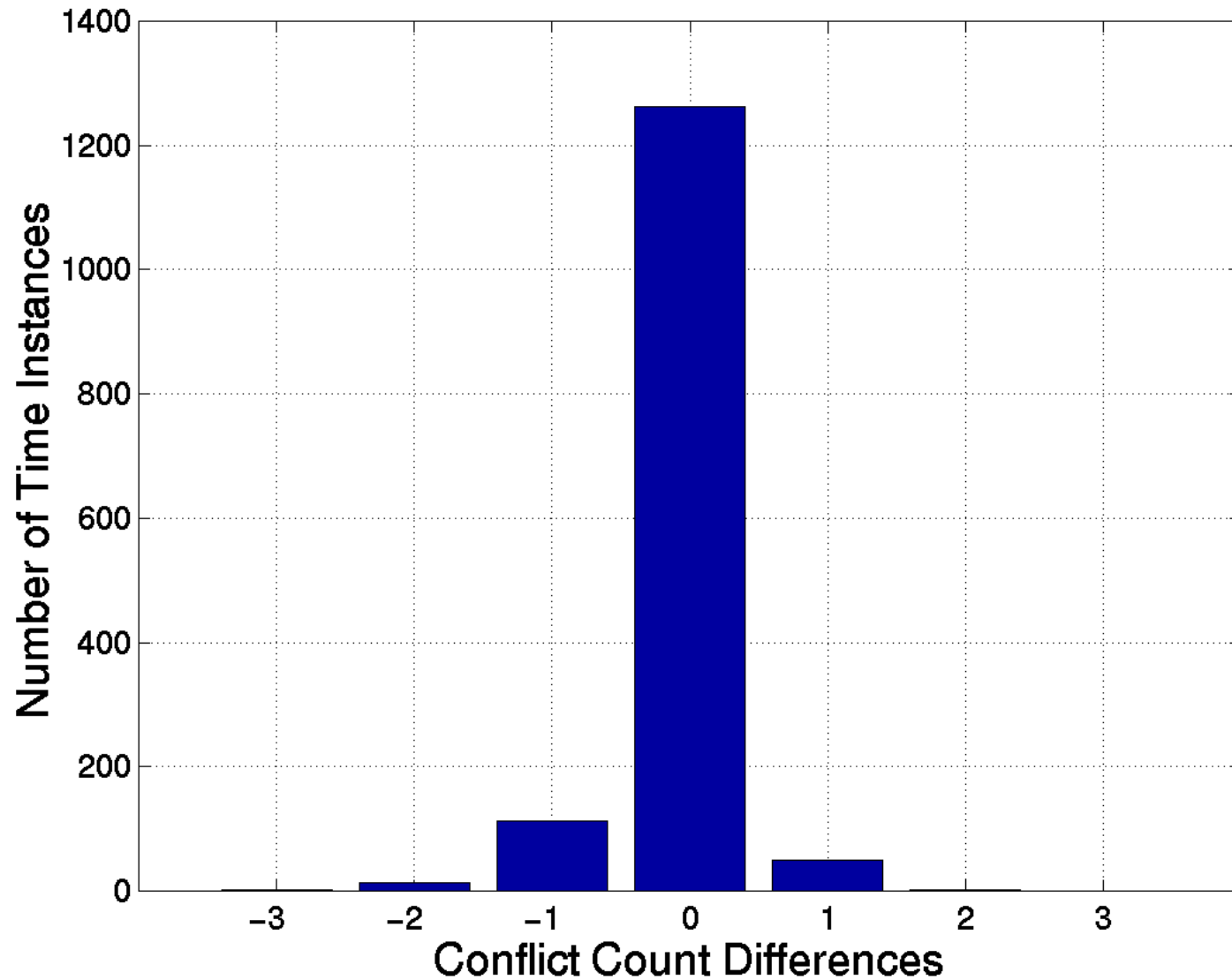


TIME HISTORY OF CONFLICTS



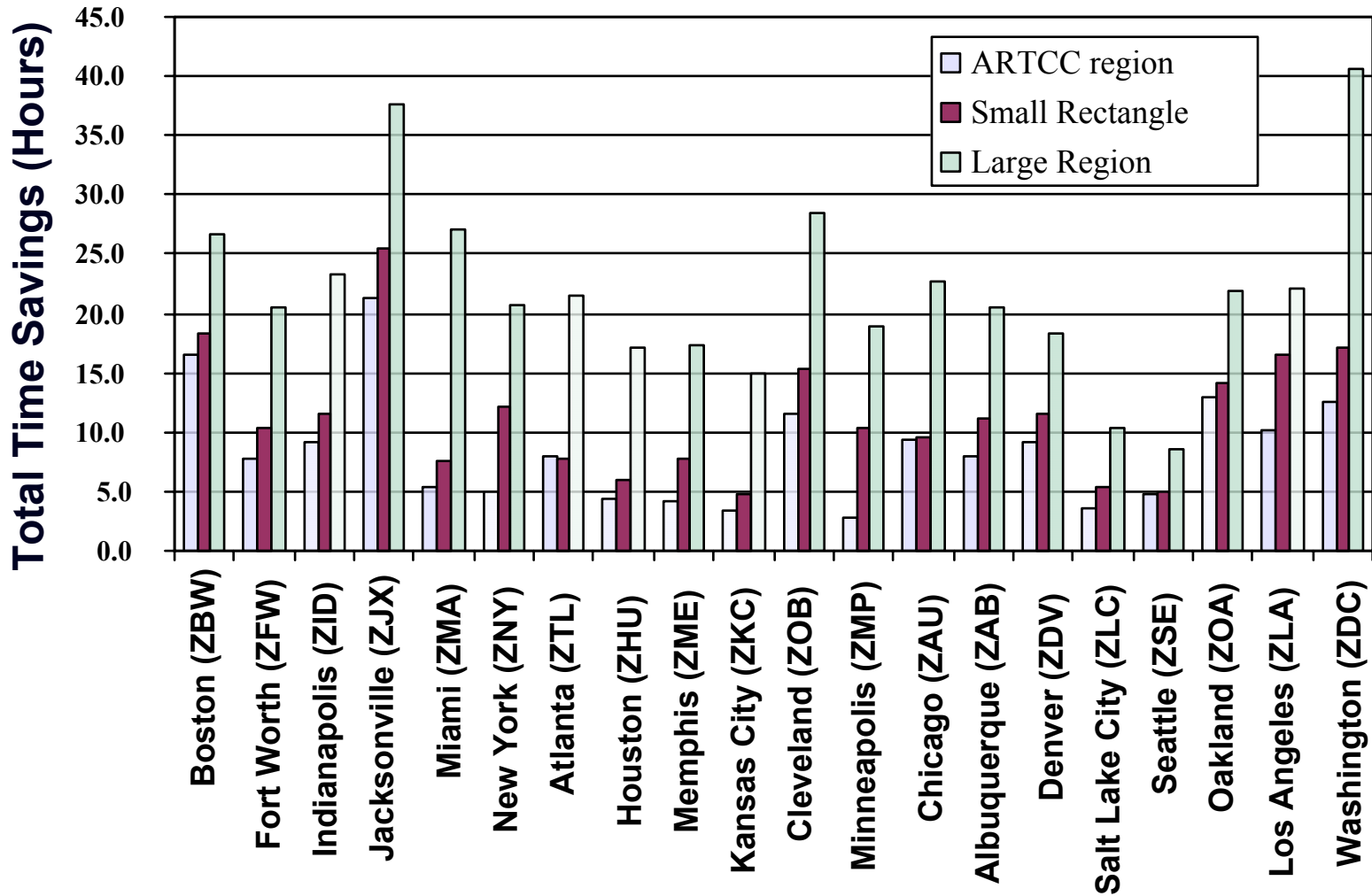


HISTOGRAM OF DIFFERENCE BETWEEN NUMBER OF CONFLICTS

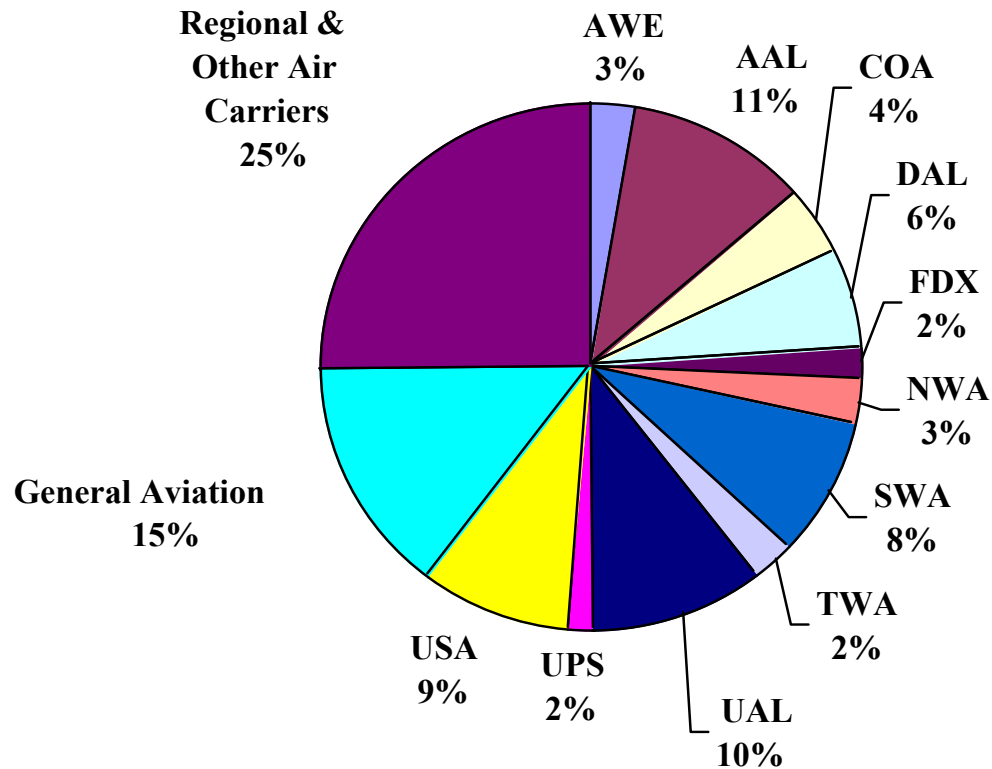




TOTAL TIME SAVINGS FOR THE 20 ARTCCS

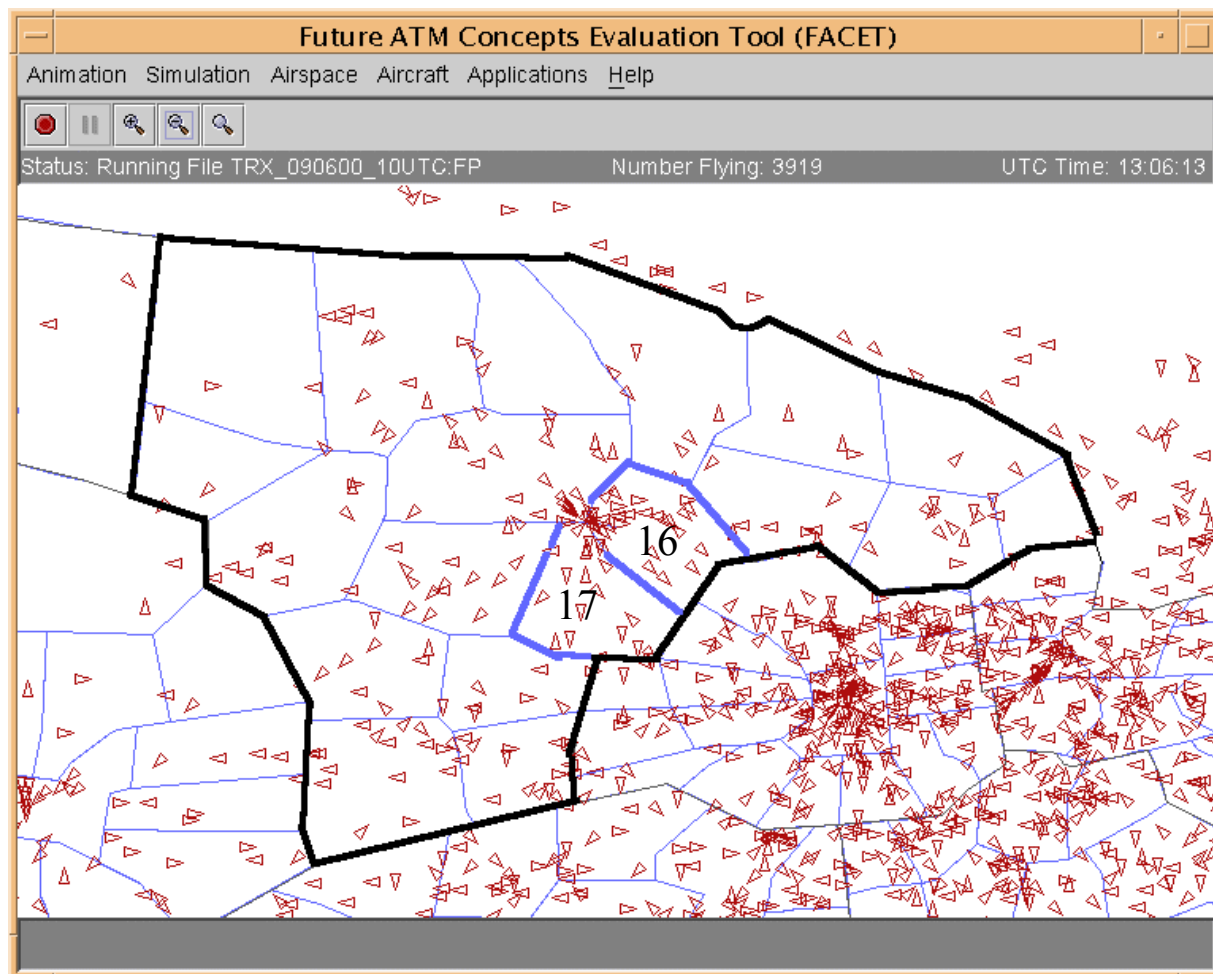


DIRECT-TO SAVINGS TO AIRLINES



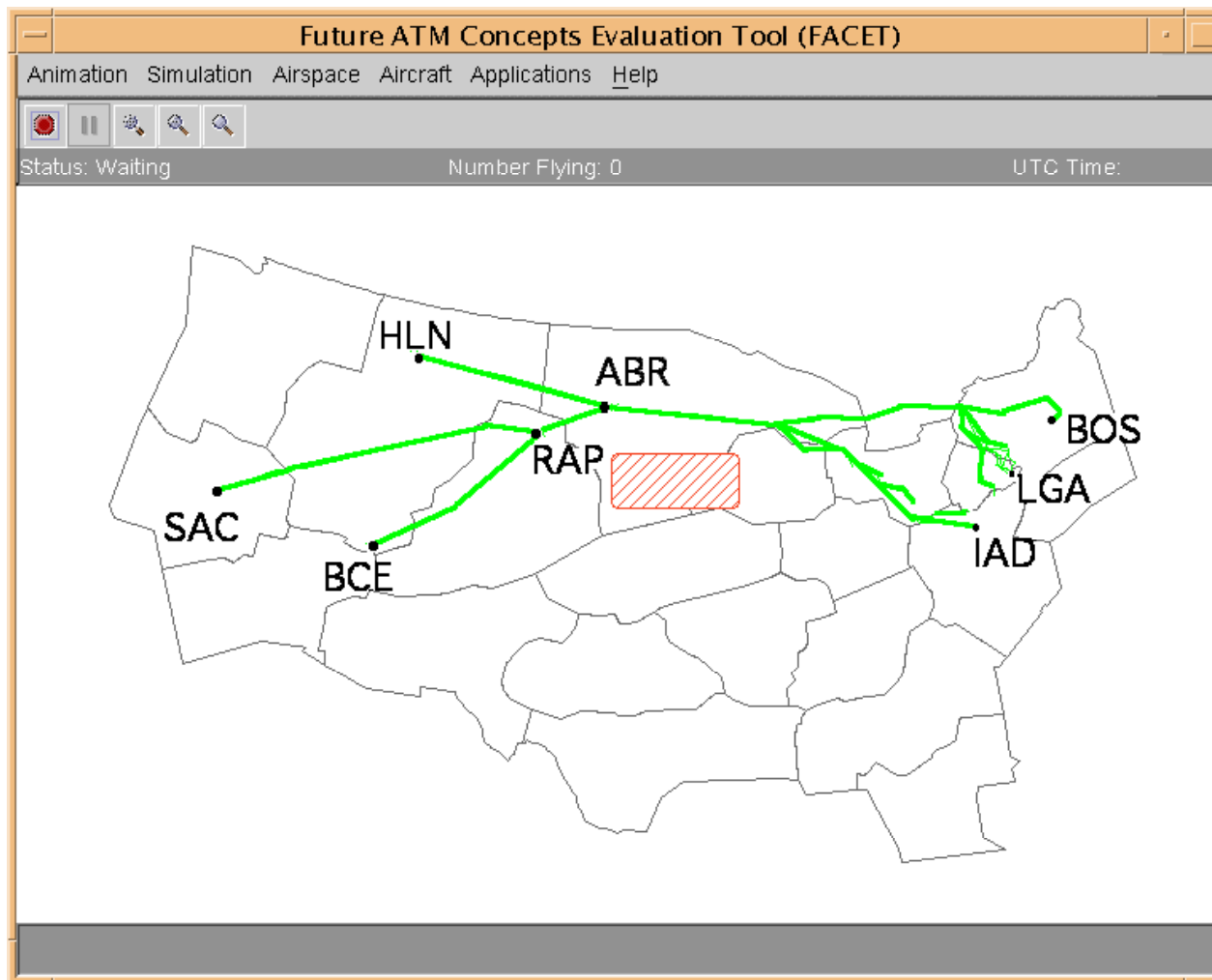
Total Savings of \$107 Million/Year
(169 hours/day at an operational cost of \$29/minute)

FACET Display

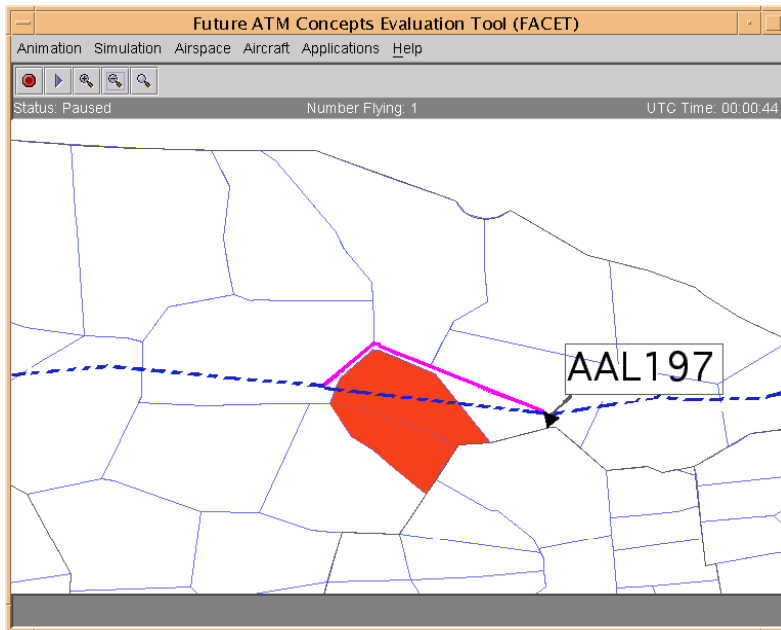


Sector Count		
File	Edit	Table
Time	ZMP16	ZMP17
Cap	18	18
00:00	16	5
00:05	17	7
00:10	19	13
00:15	16	13
00:20	11	15
00:25	10	15
00:30	8	10
00:35	9	10
00:40	8	11
00:45	8	9
00:50	10	8
00:55	9	5

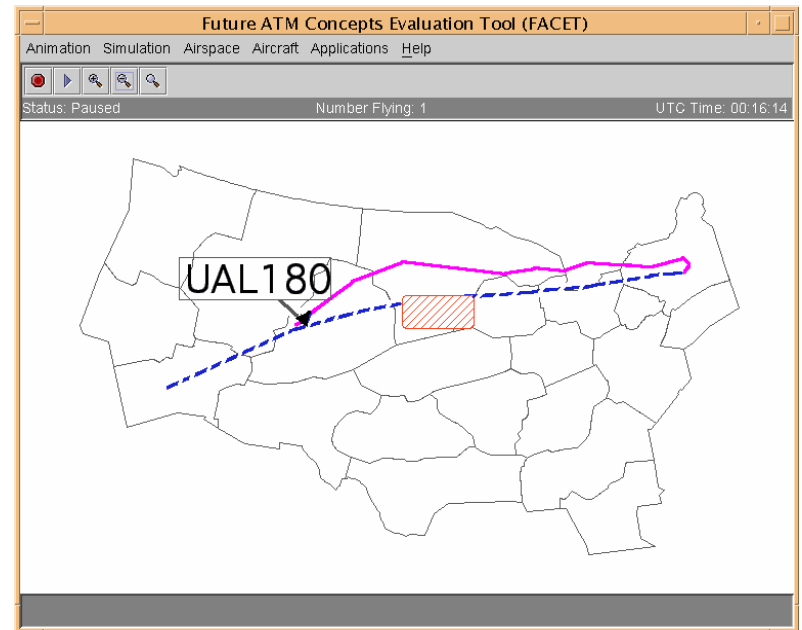
West Watertown Playbook Reroutes



Impact of different TFM actions

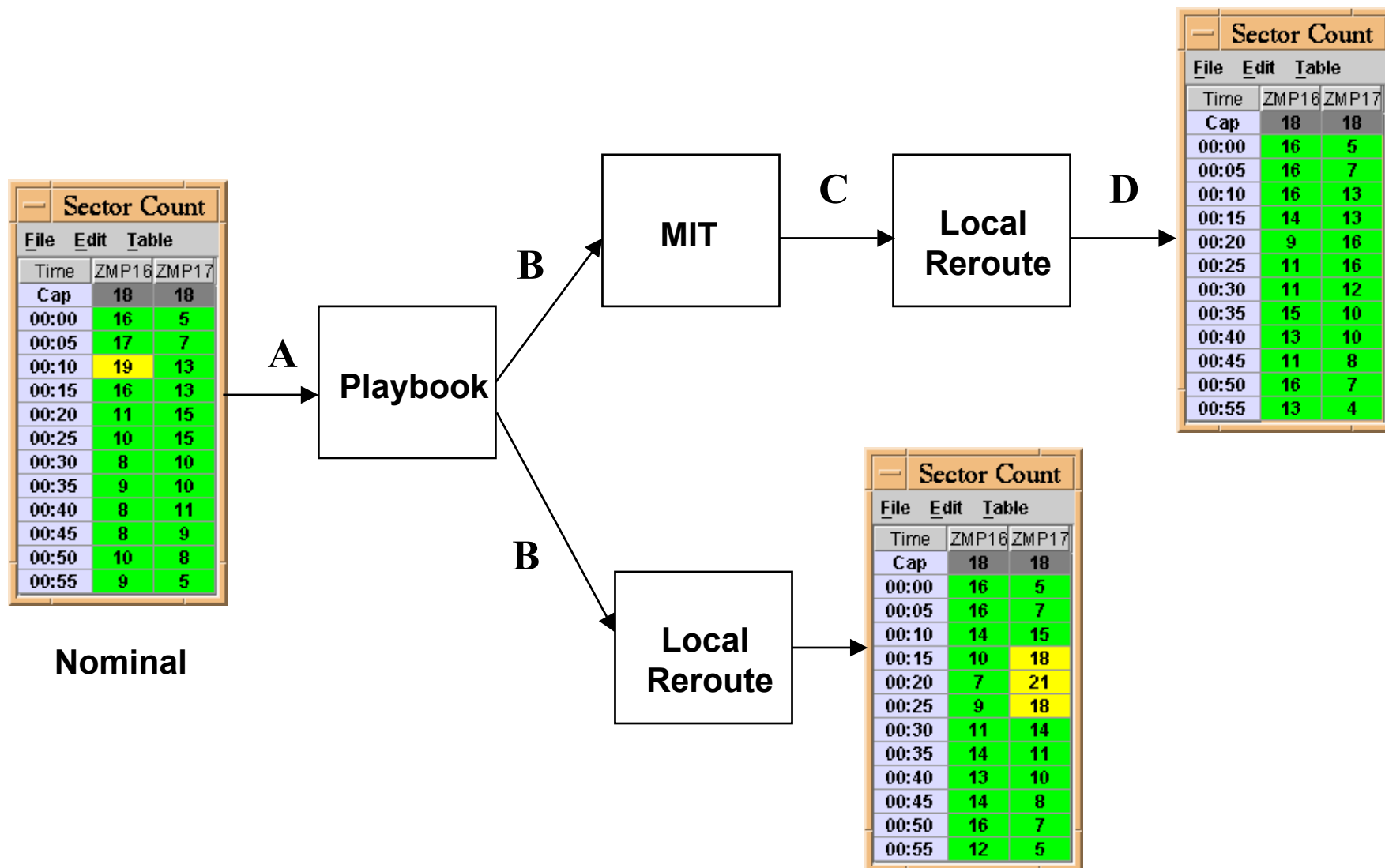


Local reroute around sector 16



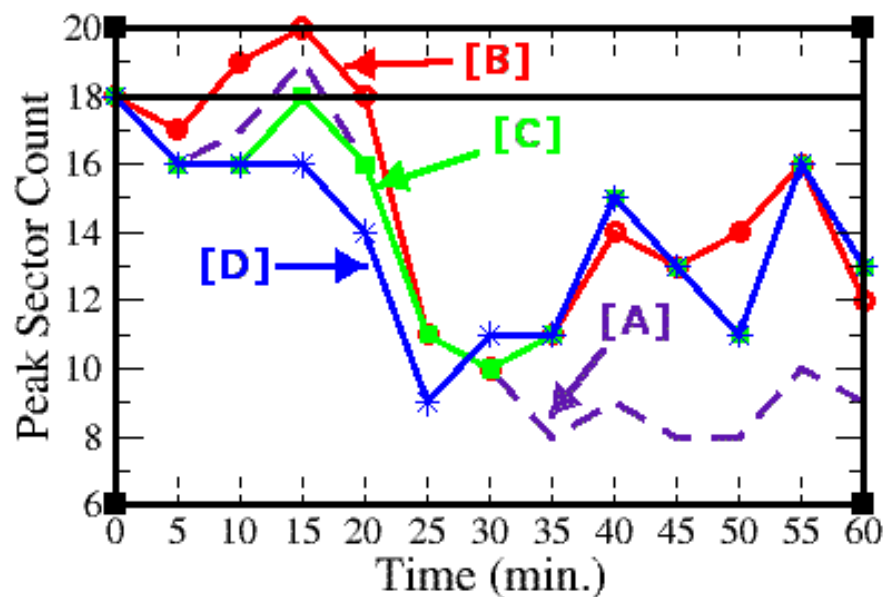
Effect of playbook re-route on a single aircraft

Alternative effects of TFM actions



Integrated traffic counts in ZMP Sector 16

[A] Nominal Counts, [B] Playbook Reroute,
[C] Playbook + MIT, [D] Playbook + MIT+Local Reroute.



Time	[A]	[B]	[C]	[D]
00:00	16-	17-	16-	16-
00:05	17-	19 +A	16-	16-
00:10	19+G	20 +G	18+G	16-
00:15	16-	18 +G	16-	14-
00:20	11-	11-	11-	9-
00:25	10-	10-	10-	11-
00:30	8-	11-	11-	11-
00:35	9-	14-	15-	15-
00:40	8-	13-	13-	13-
00:45	8-	14-	11-	11-
00:50	10-	14-	16-	16-
00:55	9-	12-	13-	13-

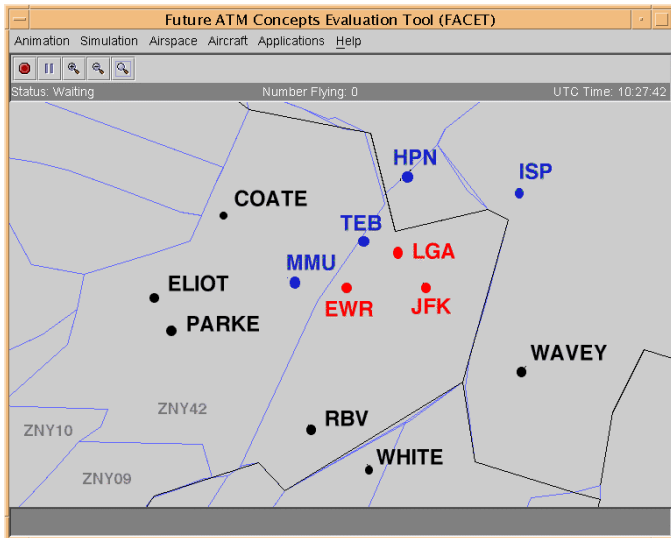
	Impacted Aircraft Count	Total Delay (min)	Average Delay (min)
Playbook	48	1448	30.16
MIT	18	48	2.69
Local Reroute	4	8.0	2.0



Traffic Management Scenario

- Each day volume at Chicago (ORD) airport leads to Chicago ARTCC (ZAU) and Cleveland ARTCC (ZOB) to place restrictions on all aircraft landing at O'Hare at specified times
- Restrictions passed on to New York ARTCC (ZNY)
- ZNY passes the restriction to New York TRACON (N90)
- Scenario uses all restrictions in effect 6/27/02
 - Focus on traffic from ZNY to ORD, CLE, and ATL

Traffic Management Scenario



Wednesday June 27, 2002 (UTC Times)

10	11	12	13	14	15
	COATE 20MIT				
	ELIOT 15 MIT				
	PARKE 15 MIT				
		RBV 15 MIT			
		WHITE 15 MIT			
		WAVEY 20 MIT			

Impact of 6/27/02 Restrictions Issued between 10:00-11:29

Sector Coun				
File	Edit	Table		
Time	ZNY09	ZNY10	ZNY39	
Cap	16	17	20	
10:00	2	5	2	
10:15	5	12	4	
10:30	7	16	5	
10:45	4	13	5	
11:00	13	11	3	
11:15	13	12	6	
11:30	9	15	5	
11:45	7	17	5	
12:00	6	20	5	
12:15	9	12	6	
12:30	14	21	4	
12:45	12	17	5	
13:00	10	13	6	
13:15	12	13	6	
13:30	9	18	5	
13:45	8	16	6	
14:00	7	14	7	
14:15	11	11	7	
14:30	6	10	5	
14:45	6	17	5	

Nominal
Counts

Sector Coun				
File	Edit	Table		
Time	ZNY09	ZNY10	ZNY39	
Cap	16	17	20	
10:00	2	5	2	
10:15	5	12	4	
10:30	7	16	3	
10:45	4	9	3	
11:00	13	7	2	
11:15	13	8	4	
11:30	9	14	3	
11:45	7	11	5	
12:00	6	8	3	
12:15	9	9	5	
12:30	13	16	6	
12:45	12	14	6	
13:00	10	12	5	
13:15	12	7	6	
13:30	7	18	6	
13:45	8	18	7	
14:00	7	15	7	
14:15	11	13	8	
14:30	7	13	6	
14:45	6	20	7	

Impact of Actual
MIT Restrictions

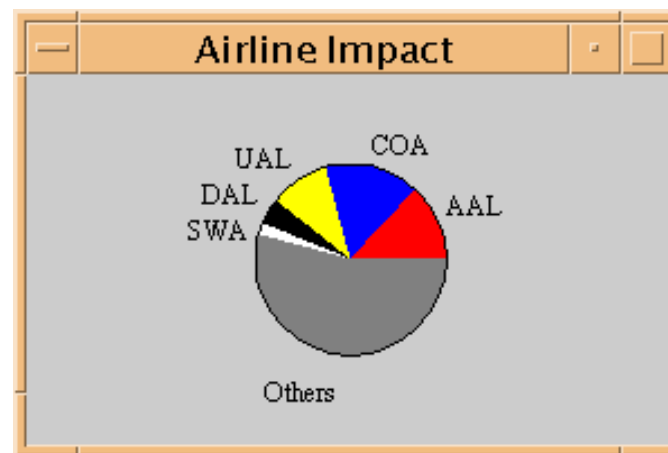
Sector Coun				
File	Edit	Table		
Time	ZNY09	ZNY10	ZNY39	
Cap	16	17	20	
10:00	2	5	2	
10:15	5	12	4	
10:30	7	16	3	
10:45	4	10	4	
11:00	13	7	2	
11:15	13	11	6	
11:30	9	16	5	
11:45	7	11	4	
12:00	6	9	4	
12:15	9	9	4	
12:30	13	15	6	
12:45	12	15	4	
13:00	10	12	5	
13:15	12	9	6	
13:30	7	19	7	
13:45	8	20	7	
14:00	7	20	8	
14:15	12	17	9	
14:30	6	13	6	
14:45	6	20	5	

ELIOT/PARKE 10-MIT
Others Unchanged

Impact of alternative ELIOT and PARKE Restrictions from 10:30 - 13:30 UTC

Restriction	Impacted Aircraft Count	Total Delay (min.)	Avg. Delay (min.)	ZNY10 Congested?
ELIOT – 10 MIT PARKE – 10 MIT	124	1030	8.3	NO
ELIOT – 10 MIT PARKE – 15 MIT	124	1741	14.0	NO
ELIOT – 15 MIT PARKE – 10 MIT	124	1940	15.6	NO
ELIOT – 15 MIT PARKE – 15 MIT	124	2651	21.4	NO

Acid	Rerouted	Metered	GDP/GS
AAL1		X	
AAL1003		X	
AAL1097		X	
AAL1143		X	
AAL1171		X	
AAL1343		X	
AAL157		X	
AAL1721		X	
AAL1893		X	
AAL2501		X	
AAL255		X	
AAL281		X	



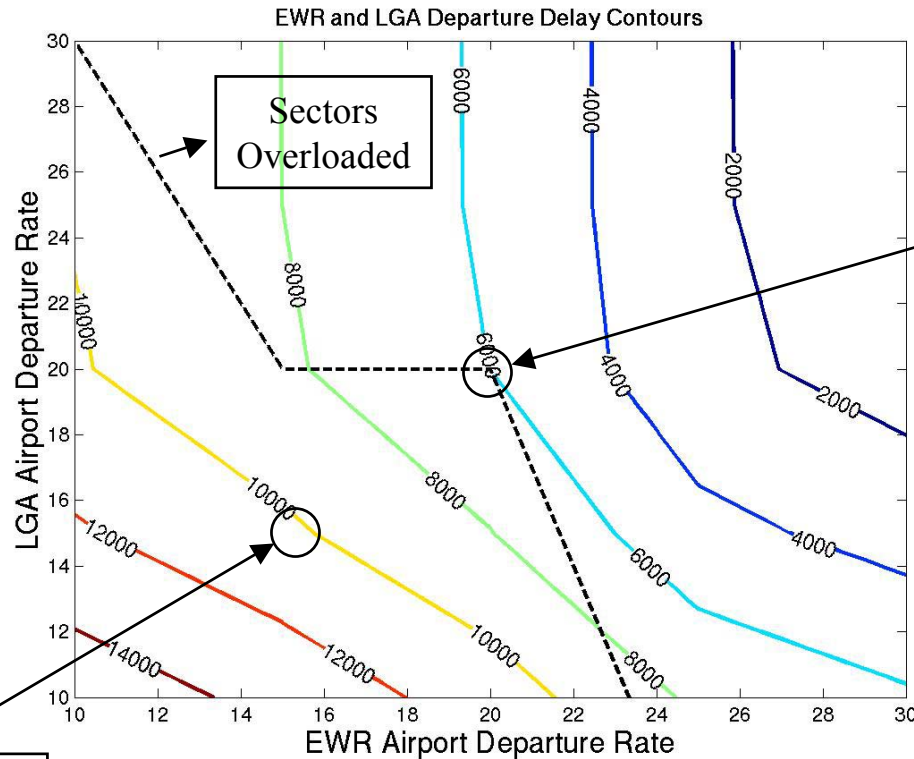
Actual Restriction on June 26, 2002: ELIOT-15 MIT, PARKE-15 MIT



Alternative Impact Assessment Capabilities

Sector ()		
File Edit Table		
Time	ZNY34	ZNY10
Cap	17	17
13:06	15	9
13:21	14	12
13:36	13	14
13:51	12	10
14:06	11	11
14:21	9	8
14:36	12	11
14:51	11	16

[A] Rerouting + Nominal
Departure Rates
Total Delay = 10361 sec.



[B] Rerouting + Optimal
Departure Rates
Total Delay = 5986 sec.

Sector ()		
File Edit Table		
Time	ZNY34	ZNY10
Cap	17	17
13:06	16	9
13:21	15	12
13:36	13	14
13:51	13	11
14:06	13	10
14:21	13	8
14:36	15	11
14:51	8	16

System demand is met with minimum delay

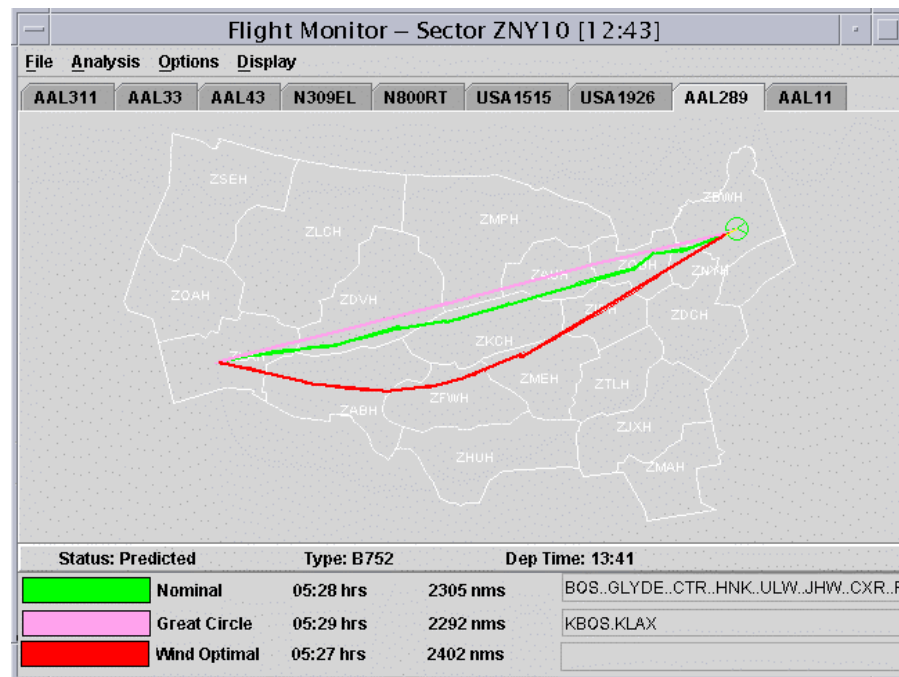


System-Wide Evaluation and Planning Tool (SWEPT)

- **SWEPT= FACET + Requirements and Modifications for FAA use**
- **Conducted interviews with TFM specialists to assess the feasibility of using FACET capabilities**
- **SWEPT envisioned to be a decision support capability for evaluating, monitoring, and analysing TFM initiatives, operational procedures, and traffic flow scenarios**
- **SWEPT has been demonstrated to SCC and CDM; FAA has recommended setting up a conformance monitoring user group for SWEPT.**
- **Working with Volpe in the development of SWEPT**
 - Integration with “Live” ETMS
 - Re-organization of functions from a user’s perspective
 - Modifications to enable a “plug-and-play” with TFM infrastructure
 - Real-time reroute conformance monitoring

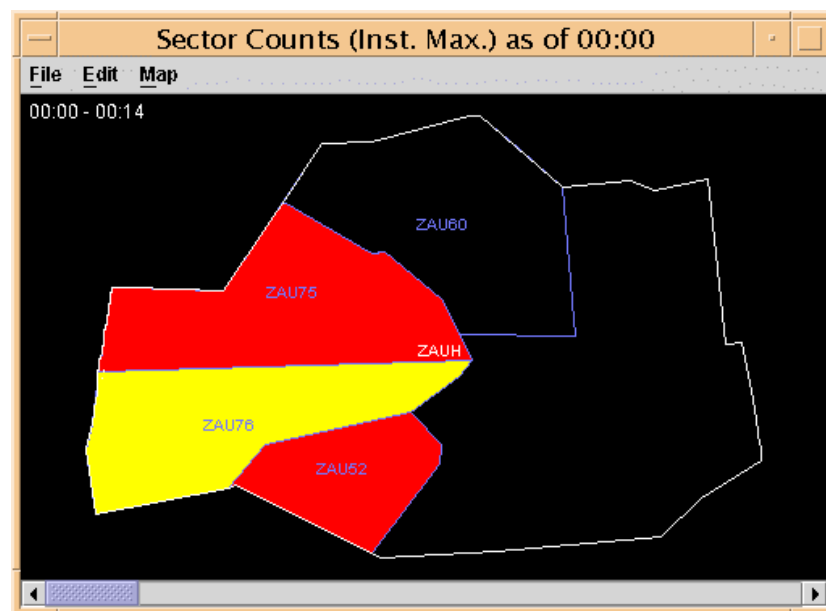
FACET-AOC

- **March 2001: request by ADF team to increase NASA research**
- **FACET modified to work with ASDI data**
- **Working with ADF and Ohio State University to develop requirements and identify research issues**
 - Dispatcher input on functionality (October 21-23 at OSU)
 - Interviews/Training for dispatchers at NWA, SWA
- **Develop functional requirements for a version of FACET for AOC use**
- **Goal is to enable timely operations planning by AOC**
 - Provide alternate routes for an aircraft routes based on business models that account for NAS congestion and constraint
 - Identify aircraft affected by FCA/SUA
 - How frequently do you plan?
 - Integration with other AOC tools

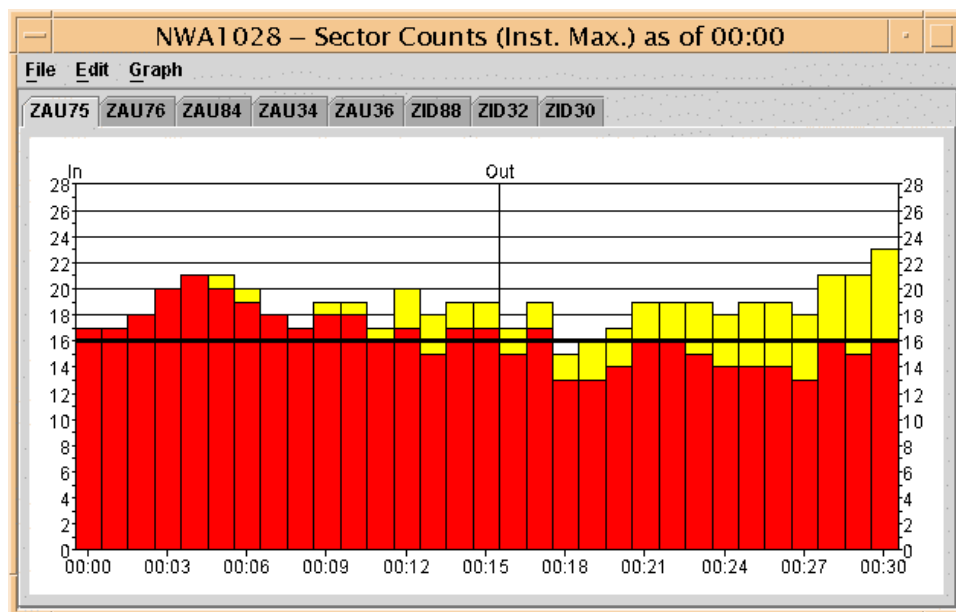
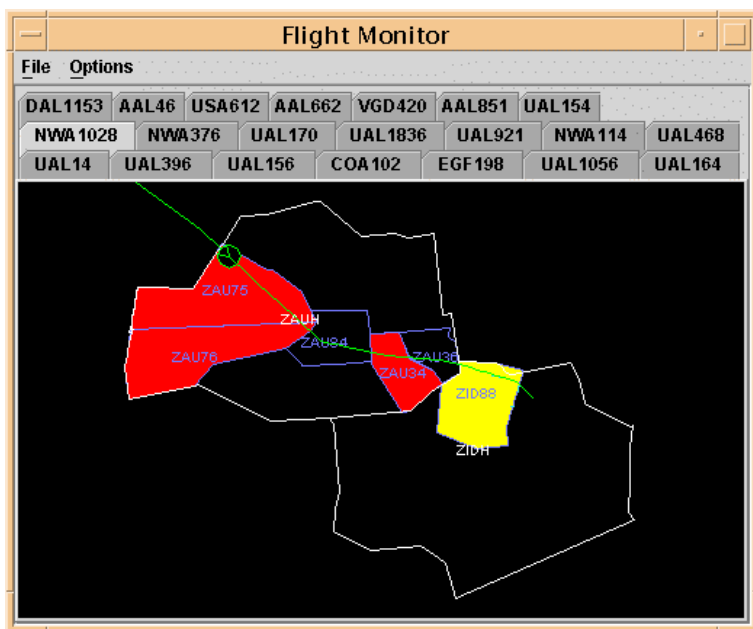


Spatial Distribution of Congested Sectors

Sector Counts				
File Edit Table				
Time	ZAU52	ZAU60	ZAU75	ZAU76
Cap	16	18	16	20
00:00	17	15	21	21
00:15	17	18	21	34
00:30	14	17	26	36
00:45	12	20	19	29
01:00	12	20	20	21
01:15	9	10	19	20
01:30	9	16	19	15
01:45	6	13	15	12

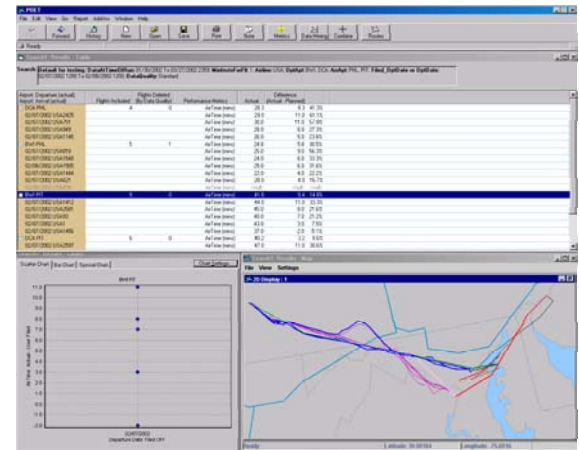
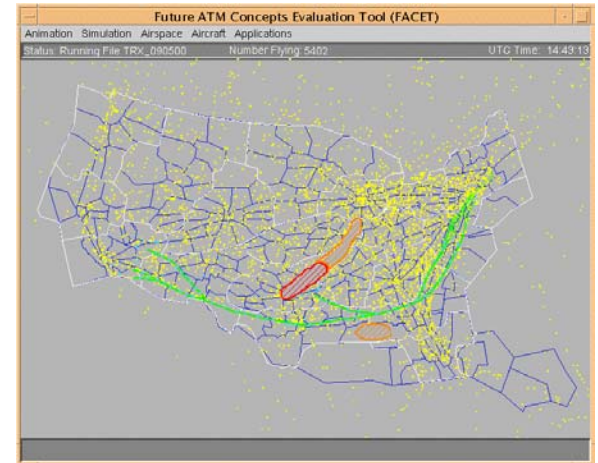


Aircraft Usage of ZAU75



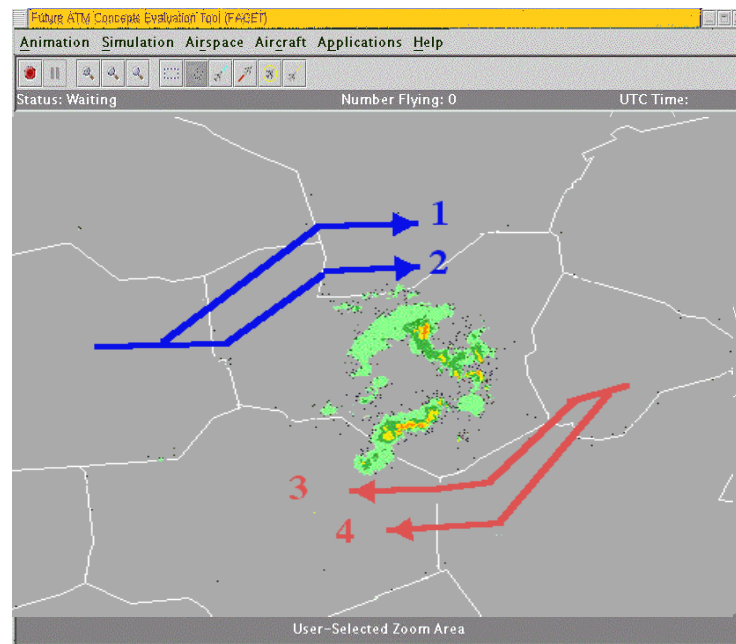
FACET-POET Integration

- **Phase 1 SBIR Project with Metron Aviation, Inc.**
- **Leverage Existing Technologies to Perform New Tasks**
 - POET provides Operational Analysis and Historical Database.
 - FACET provides Modeling and Simulation Capabilities.
- **Integrated system can be used for real-time decision making or post-operations analysis.**
 - Allows assessment of alternative TFM initiatives before implementation.
 - Historical events can be re-evaluated with alternative constraints.



Collaborative Routing Resource Allocation Tool (CRRAT)

- **Phase 2 SBIR Project with Metron Aviation, Inc.**
- **CRRAT will add en route resource allocation functionality to NASA's FACET.**
- **Goal of the project is to perform and evaluate proposed en route resource rationing schemes.**
 - Grover-Jack
 - Time-Ordered Accrued Delay (TOAD)
 - Ration-By-Schedule (RBS)
- **CAART will utilize the following control actions for alleviating en route congestion:**
 - Rerouting
 - Altitude Changes
 - Departure Delays
 - Speed Adjustments





Collaboration in the development of FACET/SWEPT

- **FAA**
 - Access to ETMS feed, facilities and operations people, Analysis using FACET (AOZ-40, ASD-130, ACT-540)
- **Volpe**
 - ETMS expertise, review of user interface, requirements
- **Metron**
 - Use of FACET for TFM tasks; Analysis using FACET
- **CSC**
 - Integration with DSP
- **ADF and Ohio State University**
 - AOC requirements, Research issues in PTFM
- **MIT Lincoln Laboratory**
 - Use of CWIS in strategic planning
- **CAASD**
 - General interaction as part of IAIP- review of sources of prediction errors, evaluating FACET for OEP analysis